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CONTROL AND TELEMAMMOGRAPHY (BREAST CANCER)

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13. ABSTRACT (Maximum 200 words) The preliminary work described above defined the data size needed for proper digital mammography, the necessary methods for image processing and requirements for display. These are essential components for making digital mammography MDIS compatible. One can duplicate the lesion detectability of screen films mammograms in phantoms with a 100 micron pixel with 2 x 2.5 K for an 8 x 10 image. A 2 x 2.5 K image can be displayed on the higher resolution MDIS monitors. 2 x 2.5 K images are comparable in size with chest images and therefore should be able to be stored in the image data base. The performance features for MDIS compatible workstation has been defined, in collaboration with a MDIS radiologist and they will be implemented and tested in year 2. We have defined the data set size needed for digital mammography. This is fundamental work for understanding and development methods for telemammography. Our preliminary tests of film scanners indicate that 100 microns may be acceptable, but that smaller pixel sizes may offer some advantages. We will be able to further test film digitization as a method once the DBA scanner arrives in January 1994.			
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**MDIS COMPATIBLE TELE-MAMMOGRAPHY:**  
**REPORT ON FIRST YEAR OF ARMY PROJECTS.**

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## **MDIS Compatible TELE-MAMMOGRAPHY: REPORT ON FIRST YEAR OF PROJECTS.**

### **1.0 INTRODUCTION:**

The first year of the project was spent gathering preliminary data essential to understanding the requirements for MDIS compatible digital mammography in image display acquisition, and processing suitable for telemammography. There are almost no publications in this field relevant to the specific work done in this project.

Although digital mammography is in limited clinical use in Europe (1,2,3,4), it is still considered an experimental technique in the United States where it has been described as being promising, but not having sufficient resolution (4,5,6) or of insufficient resolution with the possibility of improved resolution far in the future (7). Based on our experiments in system optimization, we believe we understand the disagreement in opinions is likely due either to differences in exposure factors used or differences in the image processing parameters used by different centers. Unfortunately, the actual image processing parameters used by various authors and the actual exposures used are usually not mentioned in these articles, but as our work suggests, the appropriate setting of these factors is essential to high quality digital mammography.

Based on the work we have done this year, we believe that telemammography using a number of detectors combined with appropriate image processing does equal in phantoms the resolution of conventional screen film systems at an equivalent patient dose and can exceed the object detectability of conventional screen film systems when a higher patient dose is used. The method used to arrive at the more optimal image processing settings was derived from the methods used for image optimization that we previously used with AGFA and Fuji digital imaging systems used for chest and bone images that we previously reported. (8,9)

### **2.0 THE ASSIGNED TASKS FOR THIS PROJECT ARE:**

1. MDIS Compatibility of digital mammography
2. telemammography
3. computer aided quality assurance in mammography

### **3.0 THE DISPLAY AND WORKSTATIONS FOR DIGITAL MAMMOGRAPHY:**

There are three components required for the successful development of a digital mammography system. These are the methods of image acquisition, the methods of image processing, and the methods for image display. The research from the first year has demonstrated the requirements for image acquisition and has

demonstrated appropriate parameters for portions of the necessary image processing. This project deals with investigations for image display which are at a preliminary planning stage, but some of the necessary criteria have been already defined.

### **3.1 IMAGE DISPLAY:**

Image display is an essential part of digital mammography. Conventional screen film mammography allows the display of 20 lp/mm of high contrast information. At the lower contrast range in which mammography falls however, there is somewhere between 2.5 to 5 lp/mm actual resolution. Conventional breast images are most often 8 x 10 inches, but in about 10% of cases, 10 x 12 images are produced.

There are two potential methods for the display of digital mammography: Display on workstations and display on laser prints. These two methods for display of digital mammograms are limited in their capabilities and new methods are unlikely to emerge in the near future.

When one displays digital information, the display can be of different sizes. One therefore has to consider the number of pixels in the total display as well as their spacing. Using a larger monitor does not increase the number of pixels displayed, but may display them at a size that is easier to interpret due to the magnification resulting from the larger display. With laser camera prints, the limit is 300 dots per inch. The larger the film, the more pixels that can theoretically be displayed.

### **3.2 Pixel Size and Number Related Factors:**

#### **3.2.1 Display on a Workstation:**

The highest pixel number available on workstation monitors is 2,048 x 2500 pixels. If one is projecting an image of the breast originally obtained on an 8 x 10 inch receptor, this implies that one would be limited to displaying 100 micron data if one wished to display the entire image at one time. As indicated above, this would result in an image that would approximately equal the image of screen film mammography.

If one captured the data at a smaller pixel size, one could not display the entire image at this higher pixel size, but would have to scan through the image region by region magnifying each section of the image to assure that no microcalcifications were present.

#### **3.2.2 Display on a Laser Print:**

Laser print systems are currently limited to 300 dots per inch (DPI). If one is using 14 x 17 inch film, this is equivalent to approximately 4,000 x 5,000 pixels. Thus one could display a single breast at a size of 14 x 17 inches and thus display an image that used a 50 micron pixel on an originally sized 8 x 10 inch image. If one chose to

display the image close to its original size of 8 x 10 inches, then one would be able to display the whole image with only 100 micron resolution.

### **3.2.3 The Effect of Image Display Size:**

The effects of image display size are different for monitors and laser film prints.

#### **3.3 Display on a workstation monitor:**

Workstation monitors are limited to approximately 2000 x 2500 pixels. As one changes the size of the monitor, the number of pixels remains the same, but the size of each pixel in the display changes. When radiologists interpret screen film mammography, they usually use a magnifying lens to magnify the microcalcifications to make them more apparent. Typical magnification glasses used are 2 X or 3 X magnifiers. The use of such a magnifier allows as much as 30 line pairs of high contrast detail to be seen based on tests. Thus this use of a magnifier lens exceeds the high contrast resolution of screen film mammography. The best display size for digital mammograms is yet to be determined. Based on the measurements made with the hand magnifier, we will test monitors of different sizes in 1994 using monitor displays of different sizes using image processing optimized images of breast phantoms. Our hypothesis is that displaying the image at 1.5 X normal size (12 x 15 inches) will likely provide full benefit, but we will also test larger sized monitors.

#### **3.4 Display as a laser print:**

Current laser print technology is limited to 300 dots per inch (dpi). According to our industrial sources higher resolution systems are not likely to be developed in the near future. There are at least two different methods of positioning information within each of the dots: the standard half-tone method and the Scitex patented method which divides each dot into multiple smaller dots for printing purposes. (15) The Scitex method currently only prints on paper, but appears to give a visually smoother image than halftone methods meaning that the edges of pixels are less apparent on image magnification. We are working with Scitex to test their system for the display of digital mammography.

With laser technology limited to 300 dpi, the choice of the desired resolution affects the final image display size. Currently, these have a maximal 4096 x 5000 in 14 x 17 inches. This means that each pixel in the final image is approximately 86 microns in size. If one starts with an 8 x 10 inch image of the breast and divides that image into 4000 x 5000 pixels, then each original pixel is 50 microns. Thus one can display a 50 micron image with slight magnification on a 14 x 17 laser print.

The effect of such a large image on the interperative abilities of radiologists is not known to us. This would need to be tested.

### **3.5 Look Up Table Factors:**

Laser print film and workstations have different characteristic curves than conventional screen film mammography systems. Tests would have to be performed to optimize the display of digital mammography for each potential system. Laser printers and films differ in their response characteristics and different monitors differ in their response characteristics. Procedures for measuring differences between laser systems and monitors need to be analyzed so that the optimization procedures could be applied across different manufacturers systems. We and others have done some preliminary work on monitor displays (14) and this will be an essential aspect of our work in the next two years of the project.

### **3.6 Spatial Frequency in Display Factors:**

The Optimal spatial frequency factors for image display on a workstation and on laser prints for digital mammography would have to be determined for each display system. Some laser printers have built in spatial frequency filtering. This would have to be considered in determining the best parameters for laser print display.

## **4.0 Mammography Workstation Performance Features**

The following MDIS compatible workstation performance features are the result of collaboration with Major Donald Smith, M.D., Clinical Coordinator of MDIS at the Madigan Army Medical Center.

### **4.1 Display Monitors.**

#### **General.**

The mammography workstation will have four 2.0 k x 2.5 monitors. The monitors will be arranged in an adjustable amphitheater like setting. The monitors will be used in a portrait like mode.

#### **Data Sets Available to the Monitors.**

The workstation shall accommodate individual images with a 4k x 5x by 16 bit deep images. (40 Mb of data/ image)

#### **Brightness (Luminance).**

The brighter the monitor the better as long as spot size is not compromised. The goal should be to have a monitor greater than 100 foot -lamberts.

### **Gray Scale Display.**

No fewer than 256 shades of gray (8 bits deep) displayed on each monitor shall be provided.

### **Refresh Rate.**

The monitor is to be flicker free for 95% of observers with a SMPTE pattern displayed when adjusted to 90% of maximum intensity and observed under maximum ambient illumination of not greater than 10% of the monitor intensity. This should be greater than 70 Hz.

### **Noise.**

The monitors shall not have any observable electronic noise.

### **Calibration.**

Brightness and contrast adjustment range of the monitors shall support matching of the monitor grayscale displays to < 5%. Three-month drift of monitor brightness and contrast shall be < 5%.

### **Uniformity and Distortion.**

The monitor shall have less than 15% brightness uniformity degradation from the center to the periphery. The monitor shall also have less than 3% linearity and 3% geometric distortion from center to periphery.

### **Monitor Electron Beam Spot Size.**

The spot size shall vary less than 50% from center to diagonal corner of each monitor. This is measured from a viewable area 1/2" inside the perimeter of the monitor.

### **Frame Buffer.**

Shall be no less than 16 bits deep. This is to accommodate 16 bit film digitizers now in prototype stages.

### **Random Access Memory.**

The RAM memory shall be capable of holding at least the full data set of four mammography images. Any additional images required from local storage will be accessed in a seamless and transparent manner to the user.

### **Local Storage.**

When used in a stand alone mode, the workstation will have enough memory to accomplish one day's worth of work. One strategy would be to store the exam in a compressed format on the magnetic media and decompress the data on the fly to the video frame buffer in order to reduce the local storage requirements assuming that the compression used does not significantly compromise diagnostic image quality. Each image without compression represents 4k x 6k by 12 bits deep as one prototype unit is considering.

### **Image Display Speed.**

The display of an image from local storage must be 2 seconds or faster. Redisplay of an image from RAM will be 1 second or faster.

### **Image Acquisition Input.**

The directly digital mammography images will first be viewed at a one or two monitor quality control (QC) workstation. This workstation will have similar functionality as the diagnostic workstation with multiformat image capability. It might need a 2k monitor also in order for the technologist to see if magnification or repeat images have the area(s) of subtle microcalcifications that the radiologist has requested for additional view.

### **Archive Connectivity.**

Historical images and associated reports will be loaded to the local storage of a workstation in an automatic manner from a high capacity optical archive (e.g. Optical Jukebox) based on scheduled exams list. (Alternatively, the historical reports might reside in local storage and automatically be displayed with the exam on demand. The ultimate goal is to interface to the MDIS System. Ad hoc dearchiving must be in background and take no more than 10 minutes for an old exam of four images.

## **4.2 Workstation Functions.**

### **General.**

The workstation shall provide multiple image manipulation and enhancement functions through use of a graphical user interface (GUI). The selection of these functions will be done by pull down menus, soft buttons, and quick key options. The pull down menus and soft buttons must be duplicated on each monitor. The following are required performance parameters.

### **Worklist/Patient list.**

The workstation shall automatically generate a worklist of unread (those images not already dictated) exams to enable each radiologist to review the amount of work ready for review. The worklist can be created for a specific radiologist. The worklist must include the patient name, ID number with family member prefix (FMP), date of exam, time of exam, number of images, requesting physician, and requesting location. Additional data necessary to be displayed with the image in a data window is family history, hormone replacement therapy history, and any history of biopsy. Graphical information about location of moles, biopsy scars, breast masses as well as a comment box must be available at the QC workstation for input by the technologists in a mouse driven free hand form. This worklist/ patientlist will be printed out to a printer on an ad hoc basis. When the diagnosis is made, the exam will automatically be deleted from the worklist and be placed on a recently read reviewing list. A special conference list with images will be possible with dearchiving the night before which will typically have 5-10 exams with one historical exam for each. The different worklists will be chosen by using a pull down menu option.

### **Soft Buttons.**

Various functions described below will be utilized by using an icon represented soft button on the monitors. (see appendix a) The soft button is activated by clicking the mouse driven cursor on the function desired. The soft buttons will be duplicated and displayed on all workstation monitors. They should be

logically grouped according to function. Context sensitive display of soft buttons may be used to conserve monitor real estate.

### **Image Selection.**

A mouse driven cursor selection/ deselection tool will allow individual images to be selected/ deselected for image manipulation. One option is to sequentially select images. A second option will deselect the previous choice before the next image selection so that only one image is selected at a time for image manipulation. These choices will be activated by A pull down menu or quick key option will select all images in an exam for image manipulation.

### **Image Rearrangement and Display.**

The workstation shall allow display of multiple images on a single monitor with a rearrangement capability. Rearrangement of images between monitors also shall be possible. Individual images will be moved by a mouse dragging option with overlap of images possible. A pull down menu and quick key options will arrange the images in the closest fit for the multiformat option chosen.

### **Multiformat Image Tool.**

The workstation will have the interactive option to display multiple images across multiple monitors in a 1:1, 2:1, 4:1 and 6:1 option as a minimum. (e.g., a current and three previous mammography exams are to be compared. Each exam has two CC and two MLO views. The 4:1 image option will allow all the exams to be viewed across four monitors in a minified view , four images of one exam seen on each monitor.) The images will be sized to fit the monitor viewing boundary automatically. The multiformat selections will be chosen by pull down menu, quick keys, and monitor soft buttons. These images would be enlarged to full monitor size by the tool described below. A page up and down soft button and quick key will be available when more images are available than displayed on one or more monitors depending on the multiformat and default display protocol chosen. (e.g., six images are available and a 1:1 format was chosen. A page down button would display the remaining two images on monitors A and B of a four monitor workstation.)

### **Double Click Image to Full Size.**

An Image displayed in a multiformat manner will be enlarged to full monitor viewable size by a double click of the mouse button. The double click of the image again will minify the image back to the previously selected multiformat size. Each monitor will act independently of each other as this tool is utilized.

### **Default Display Protocol.**

This required function displays the images of a patient study in a user-selectable protocol, activated each time the individual user logs on the workstation. If no individual default exists for the user, the department default and protocol is utilized. (See Appendix A for details of these protocols.) Ideally the software will recognize Right, Left, Cranio-Caudad, Medial-Lateral-Oblique, Direct Medial-Lateral, and other special image view images as identified initially by the technologist. In most cases the position of the breast for the standard views will be the same allowing for easy identification of the type and orientation of the images. As a minimum, the correct orientation of the image will be presented to the Radiologist as part of the default display protocols below. The different presets for these protocols will be activated by pull down menu, quick keys, or soft buttons.

### **Next Exam.**

A pull down menu, quick key, and soft button will be available for choosing the next exam on the worklist awaiting diagnosis. This will also close the exam that was just read and diagnosed. The option to skip the current exam (needing additional views for a current or call-back patient) and go on the next exam will be available. The next exam displayed will follow the default display protocols as above.

### **Image Enhancements Defaults.**

The workstation shall include multiple user-selectable image enhancement defaults for gray scale windowing and leveling, variable degrees of edge enhancement, and inverse video, activated each time the individual user logs on the workstation. The images of an exam displayed will automatically be window and leveled at a user's and/or departmental default. These defaults will be easily modified by the user and be activated by pull down menu and quick key options.

### **Edge Enhancement.**

The workstation shall process and display the image with a user selectable degree of edge enhancement (e.g., unsharp masking). Different kernel sizes, Enhancement boost factor, and energy dependent differential filtering will be possible. The entire image will be processed with the selected variables in less than 2 seconds. The edge enhancement presets will be activated by use of a pull down menu or quick keys.

### **Window and Level.**

The workstation shall provide dynamic window and level through the entire image gray scale data set. This function shall be provided for images on all monitors, a single monitor, or a specified region of interest on a single monitor. This function will operate in a rapidly smooth and continuous manner when applied to the entire image in a 1:1 displayed option on the 2k monitor. The window/ level will be applied only to the images selected (See section II. no. 4, "Image Selection") which may be all images or only a selected subset of an exam. This function will be chosen by pull down menu, quick key, or soft button.

### **Inverse Video.**

Display of the inverse video of the whole image or any selected region of interest shall be supported. This function will be selected by pull down menu or quick key options. In inverse video, the system shall detect the skin edge of the breast and automatically blacken the region outside of the patient

### **Cursor.**

The workstation control cursor shall move easily within and between monitors in a smooth continuous manner. The cursor shall always be visible during its movement. Cursor movement shall be controlled with a pointing device (mouse or trackball). The use of keyboard keys for the image cursor movement is not acceptable. A orientation arrow at the top of the monitor will identify the direction to find the cursor location when lost among the four monitors. A user configurable accelerometer function will be provided for the mouse. This functions allows for differential speed of the cursor movement for

fine movements versus moving the cursor quickly (e.g., moving the cursor from the left hand monitor to the right hand monitor. Various image manipulation tools when selected will have an identifying cursor to indicate that choice. (e.g., When the measurement tool is used, a cross hair cursor will be over the image to indicate the function selected.)

### **Screen Blanking.**

The workstation shall include automatic screen blanking with a user-selectable time default.

### **Automatic Shutdown.**

A user selectable time elapse of workstation non-use will cause the workstation and monitors to shut down.

### **Zoom.**

The workstation shall be capable of enlarging the workstation two and four times and display it by simple replication of pixel values. The workstation shall also be capable of variably enlarging the image display it by interpolation. The image will zoom about the user selectable point (e.g., the location of the cursor when the function is activated.) This function will operate in a continuously smooth manner when rapidly done. This tool will be selected by pull down menu, quick keys or soft button. When zoom is activated, a quick key while depressed will allow for the mouse driven image roam function (see below).

### **Image Roam.**

The workstation shall provide **rapidly smooth continuous movement** of a 4K by 5K by 16 bit image data set or zoomed portion of the image in the workstation memory through a 2K by 2.5K window monitor utilized in the mammography workstation. This tool will be selected by pull down menu, quick key, or soft button.

### **Digital Magnifying Glass.**

The workstation shall be able to display the full data set of a computed radiography image within a quickly resizeable moving region of interest (ROI).

This function will be **rapidly smooth and continuous when operated**. The digital magnifying option will be chosen by pull down menu or soft button. The function within a ROI will occur by use of depressing the mouse button and moving the mouse. The resizing of the ROI will occur during the use of a quick key while depressed. The window/ level within the actively used digital magnifying glass ROI will be interactively changed while depressing the window/ level quick key. Likewise, a quick key will allow differential degrees of magnification within the activated digital magnifying glass ROI to be interactively selected. Inverse video gray scale will be supported in the moving digital magnifying glass ROI selectable by pull down menu option or quick key.

### **Rotation and Flip.**

The workstation shall allow sequential 90 degree clockwise and counter-clockwise rotation of the image as well as 180 degree flip in the horizontal and vertical axes.(e.g., right to left or top to bottom). The new orientation shall be saved for future retrieval. These functions will be activated by pull down menu or soft buttons.

### **Mensuration.**

The workstation shall compute point-to-point measurement with automatically calibrated, user-selectable scales (e.g., cm or inches). It shall also perform angular measurement, area and perimeter measurement based on ellipses and pointing device control tracing. The workstation shall compute and display these functions for multiple measurements simultaneously (10 or less) on the same image and save them as an overlay which can be toggled on and off. When multiple measurements are made on the same image, a legend will identify each of the measurements to the location measured. These options will be activated by use of the pull down menu, quick keys, or soft buttons.

### **Text and Graphics Annotations.**

The workstation shall utilize and display user-selectable locations and orientations for graphic symbols (e.g., arrowheads and circles) and text annotation with simultaneous displays on the same image. Free hand tracing

shall be possible. The annotation(s) shall be saved as an overlay which can be toggled on and off. This tool will be activated by pull down menu or soft button.

### **Image Identification.**

When the images are displayed, the images shall be identified with the following patient data as a minimum; patient name, social security account number (SSAN) with the family member prefix (FMP), and the exam date and time.

### **Delete.**

The workstation shall be capable of user-selected auto-delete from local storage, and allow marking of selected images for non- deletion. Typically this will be a first in first out, however, some exams awaiting additional views will need to be kept on local storage until the view is acquired and the diagnosis made. This should be a pull down menu option only.

### **Hard Copy Generation.**

The workstation shall include a one keystroke equivalent (OKSE) method for image hard copy generation of an image or exam selected from the workstation console. The goal here will be to interface to the MDIS networked laser image printer. An additional strategy will be to provide an ultra high resolution paper printer or quick photo device (e.g., Sony) for printing of selected images or exams. In most cases this will probably be sufficient for the referring clinician. This function will be chosen by pull down menu.

### **Command Reversal (Undo).**

The workstation shall be capable of reversing the last one key command and in the event that the command is not reversible the operating system shall indicate such a condition by a warning signal issued prior to executing the requested command. If a command is given which will take an extended length of time, then an abort function will be provided. This function will be operated by pull down menu or quick key options.

### **Save.**

The exams involving research and teaching images shall be identified in the database for future easy retrieval. This function will be operated by pull down menu or quick key options.

### **System is Working (SIW).**

User operations that require time delays, for example some image processing operations, shall be indicated on the screen (e.g., a ticking icon) to let the user know that the operation is underway and the system is operating. At user option, this process can be shifted to background so that other work can continue.

### **Reporting.**

The workstation will allow the use of the ACR software reporting software, Breast Imaging Reporting Database (BIRD), program. This program provides the standard lexicon of terms used in mammography reports. This approach may require an additional standard VGA monitor and CPU integrated as far as data sharing with the diagnostic workstation but usable with a separate or same mouse as two options. The separate mouse would be used when a staff radiologist is working with a resident and one could be using the diagnostic workstation and the other is inputting the report. A single mouse would be used when only one person was working. (Point of Contact for the software is Nick Croce, American College of Radiology, 800-227-5463 or 800-553-8996). A laser printer will be connectable to the workstation for hardcopy report generation. The analysis of the database information will be possible using Microsoft Excel or like spread sheet. This tool will be chosen by pull down menu or quick key options.

### **Follow-up Exams.**

The exams that require an additional view when the patient must be called back must be tracked in an effective and transparent way to the technologist and radiologists. A utility to confirm the follow up exam that is requested has been accomplished is mandatory. A method to place the exam back on a specific radiologist's worklist is necessary. An option to log in scheduled

absences of the radiologist is needed so that any call back patients will have their exam interpreted without delay by the reader for that day. This way the routinely assigned mammographer for the day will read the call back exam. The list of call-back patients will have access to the patient demographic data, especially the patient's phone number.

#### **Additional Image Marking.**

A moveable region of interest for focal cone compression, focal cone magnification compression or simple magnification at 1.5 magnification (or other designated magnification factor) will be identified within a fixed field of view for a given image. This image shall be stored as an overlay to the original image. This information will be sent back to the QC workstation to be matched up with the patient's image for technologist reference in order to accomplish the additional view(s). The images obtained as focal cone compression, focal cone magnified or simple Magnification views will marked as such on the image along with the degree of magnification. The ROI will be moved to the area of concern by using the mouse and deposited with a mouse click. These choices will be indicated by pull down menu, quick key, or soft buttons.

#### **Surgical and Core Biopsy Results Input.**

A method to quickly input the pathology results from surgery and core biopsies into the patient database will be provided. Ideally, this input can be input to the QC workstation and then downloaded to the mammo diagnostic workstation. by using standard site configurable language. The selections will be mouse driven with input of non-standard language by keyboard use. Scheduling of patient biopsies will be part of the results reporting utility.

#### **Automatic Adaptive Histogram Equalization.**

Automatic adaptive histogram equalization will be provided as a toggled option for optimal softcopy display of mammographic images. This will be a pull down menu option only.

## **Automatic Capture of Mammographic Technique Exposure Parameters.**

The exposure factors will be part of the patient database information on the QC workstation. This information will automatically be sent with the image to the QC workstation and will include as a minimum the Kvp, Mas, thickness of the breast as compressed, and source to skin distance. This information should be captured at the time of mammographic exposure by linking the automatic exposure record (whenever the mammographic machine provides it) to the barcode of the imaging plate or direct image capture host processor. The link of the exposure information to the imaging plate barcode may precede or follow the link between the patient ID barcode and imaging plate barcode in the case of using a separate phosphor plate as the image receptor.

## **Computer Assisted Diagnosis (CADx).**

The workstation must be Cadx hardware capable. The image processing must occur automatically in background and not interfere with interactive image manipulation for the displayed exam. The CADx for a four image exam must take less than 30 seconds. At least three different levels of sensitivity must be user selectable. The displayed areas of interest identifying masses and microcalcifications will be marked with variable size graphics (e.g., circles or arrowheads) that can be toggled on and off. The variable size of the markers as an overlay will indicate the position and degree of confidence of the finding being a true positive. When the user is ready for display of this overlay a pull down menu, quick key, or soft button will be used. The CADx software should also allow for a pointing function to allow the user to select a ROI and query the CADx program for its analysis of that location.

## **Automatic Orientation.**

An automatic image position recognition program shall be included. It shall identify the metal marker used to identify patient position. The location of the metal marker shall automatically orient the image so that the image is displayed with the location of the metal marker in the superior part of the image as displayed.

**Exam Quality Control.**

A utility for correcting the wrong patient name, left/ right position or type of view imaged (e.g., C-C labeling of the image) shall be provided.

**Electronic Shutter.**

The area of each exposed image without breast tissue will appear on the monitor as a "blackened" portion to reduce the ambient light and glare. This will be an automatic background function. When the image is displayed as a reverse video, the region outside of the skin edge will be identified and the image reversed locally in that region so that the display is black.

**Pathology Specimen Imaging.**

Database, worklist, and imaging support to radiograph surgical and core biopsy specimens will be available.

**Security.**

Each authorized user of the workstation must use a password system to logon.

## **5.0 SUMMARY:**

During the first year of this research grant we have done a large number of small projects to define the essential parameters for digital mammography to be successful. We believe that our work to date has given us a much better understanding of the parameters necessary for proper image acquisition, image processing and display, and that this preliminary data will allow us to proceed rapidly with the remainder of the project.

This project was focused in defining the characteristics of existing digital mammographic systems and to test their applicability for digital mammography as a replacement for conventional mammography.

## **6.0 THE ASSIGNED TASKS FOR THIS PROJECT ARE:**

### *RELEVANCE OF THIS WORK TO MDIS COMPATIBILITY:*

The preliminary work described above defined the data size needed for proper digital mammography, the necessary methods for image processing and requirements for display. These are essential components for making digital mammography MDIS compatible. One can duplicate the lesion detectability of screen films mammograms in phantoms with a 100 micron pixel with  $2 \times 2.5$  K for an  $8 \times 10$  image. A  $2 \times 2.5$  K image can be displayed on the higher resolution MDIS monitors.  $2 \times 2.5$  K images are comparable in size with chest images and therefore should be able to be stored in the image data base.

The image processing capabilities currently available in MDIS are simulations of the processes used in the image processing in our experiments. Thus it should be possible to store and transmit digital mammographic images in the MDIS environment. The actual methods for doing this will be worked on in later parts of the project.

### *RELEVANCE OF THIS WORK TO TELEMAMMOGRAPHY:*

We have defined the data set size needed for digital mammography. This is fundamental work for understanding and development methods for telemammography. Our preliminary tests of film scanners indicate that 100 microns may be acceptable, but that smaller pixel sizes may offer some advantages. We will be able to further test film digitization as a method once the DBA scanner arrives in January, 1994.

### *RELEVANCE OF THIS WORK TO COMPUTER AIDED QUALITY ASSURANCE:*

Work on this part of the project will begin in 1994. The data we have gathered on the relationship of exposure to diagnostic findings will be one of the features analysed in the computer aided quality assurance projects.

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